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GB 2167869 A EP 0501165 A

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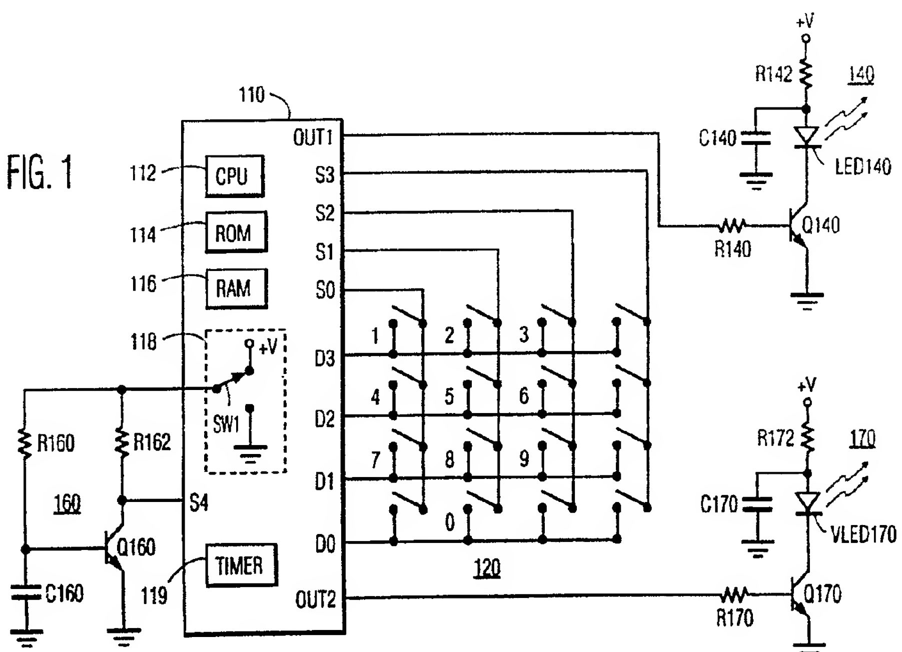
UK CL (Edition M) G1U UR19165 UR3136, H3H HAC
INT CL^5 G01R 19/165 31/36, H03M 1/50 1/52
ONLINE DATABASES:WPI,CLAIMS

(54) **Low voltage detection circuit for use in a remote control unit**

(57) A battery monitoring apparatus 110 in a remote control unit measures the time it takes for a charging circuit C160 connected to the battery +V, to charge to a predetermined level. A weak battery takes a longer time to charge than does a fully charged battery. The charging time associated with a fully charged battery is measured by a timer 119 and recorded in a RAM 116 and compared to subsequent charging time measurements. When the difference between the recorded charging time and a currently-measured charging time exceeds a predetermined value, a weak-battery alert signal is generated. In one embodiment, the alert signal is applied to a visible LED driver circuit 170; in another embodiment, the weak=battery alert signal is transmitted to the controlled equipment which alerts the user.



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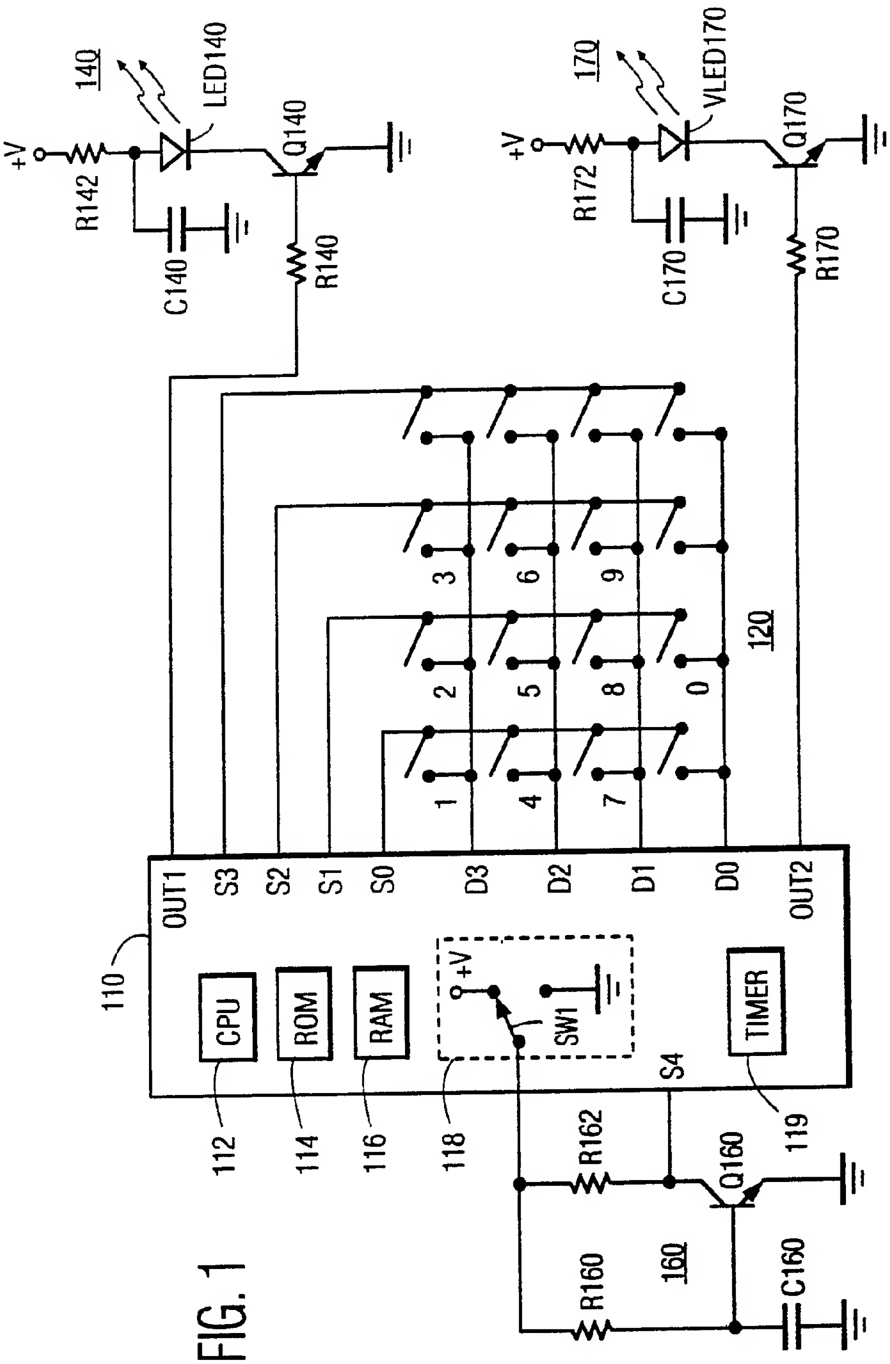
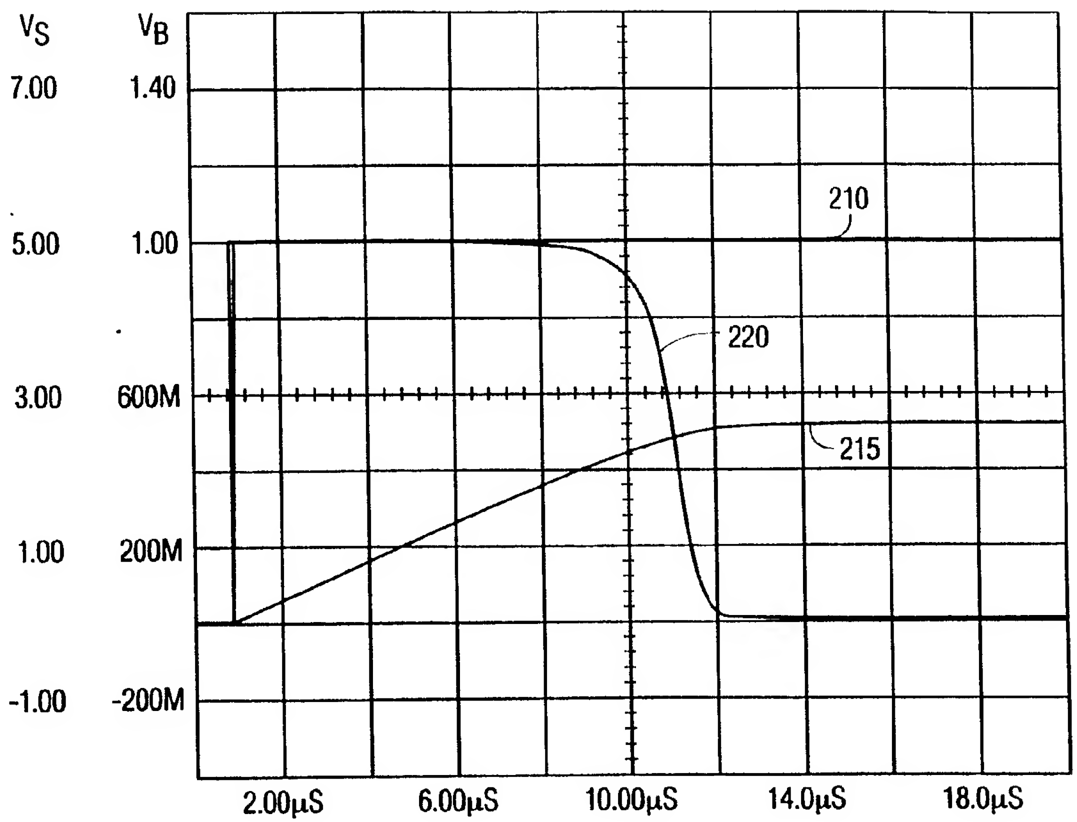
This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1990.



+V
R142
C140
R140
140
LED140
Q140
+V
R172
C170
R170
170
VLED170
Q170
1
2
3
4
5
6
7
8
9
0
120
110
OUT1
S3
S2
S1
S0
D3
D2
D1
D0
OUT2
CPU
ROM
RAM
+V
SW1
TIMER
S4
112
114
116
118
119
R162
Q160
R160
160
C160

FIG. 1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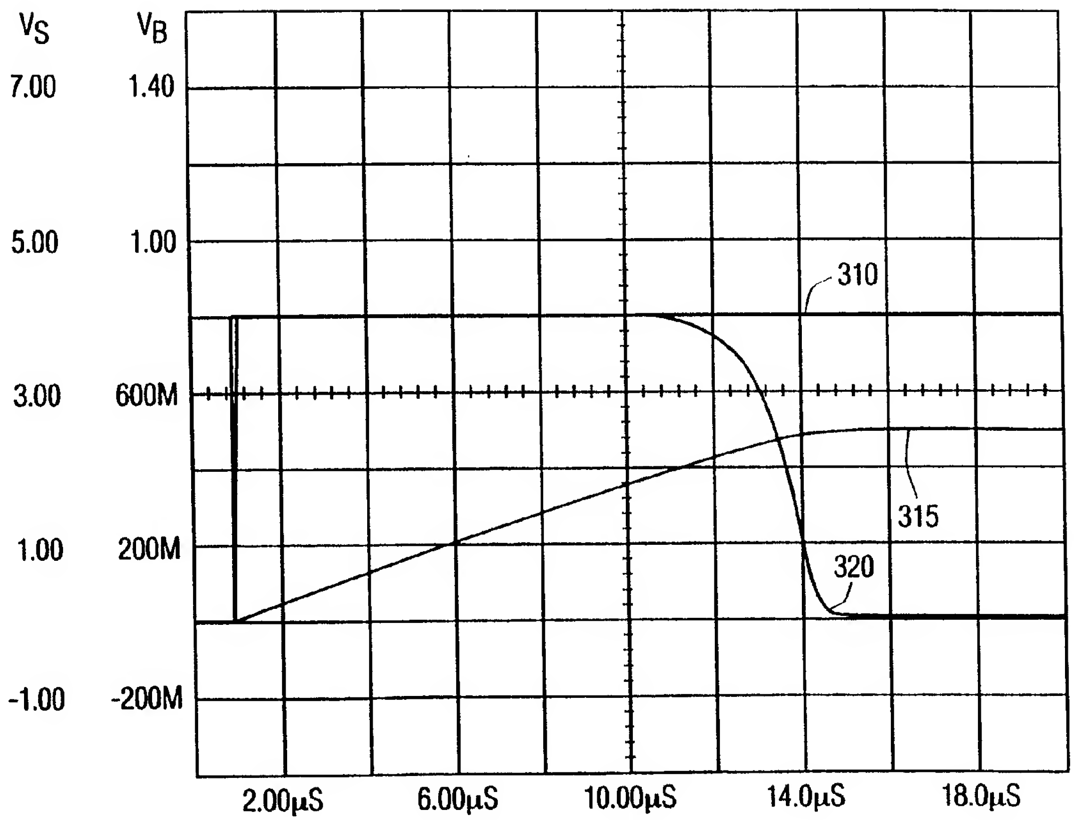
V_B
7.00
1.40
5.00
1.00
3.00
600M
1.00
200M
-1.00
-200M
210
220
215
2.00μS
6.00μS
10.00μS
14.0μS
18.0μS

FIG. 2


V_S
V_B
7.00
1.40
5.00
1.00
3.00
600M
1.00
200M
-1.00
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6.00μS
10.00μS
14.0μS
18.0μS
310
315
320

FIG. 3

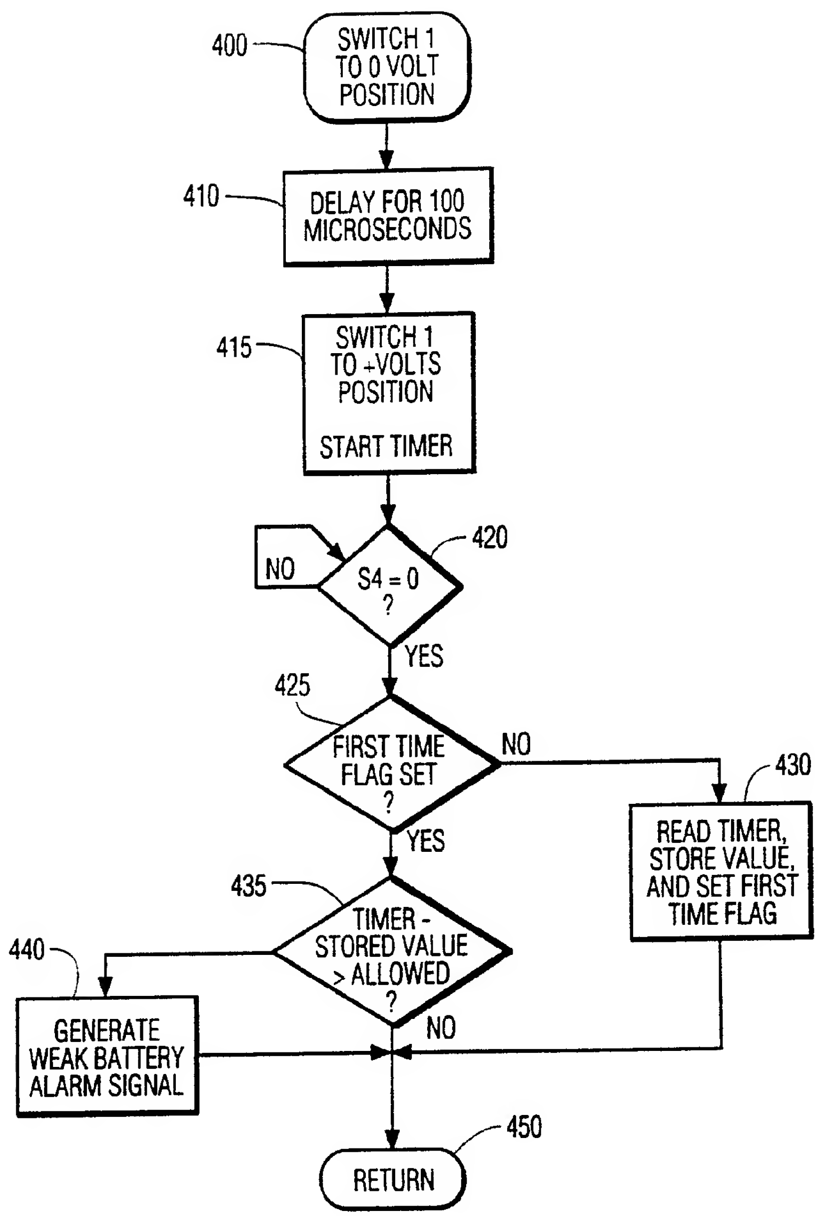
SWITCH 1 TO 0 VOLT POSITION
400
DELAY FOR 100 MICROSECONDS
410
SWITCH 1 TO +VOLTS POSITION
START TIMER
415
S4 = 0 ?
420
NO
YES
FIRST TIME FLAG SET ?
425
NO
YES
READ TIMER, STORE VALUE, AND SET FIRST TIME FLAG
430
TIMER - STORED VALUE > ALLOWED ?
435
NO
GENERATE WEAK BATTERY ALARM SIGNAL
440
RETURN
450

FIG.4

LOW VOLTAGE DETECTION CIRCUIT FOR USE IN A REMOTE CONTROL UNIT

This invention concerns remote control units, in general, and, in particular, a remote control unit having a battery monitoring circuit, and a method of determining the condition of a battery.

Wireless remote control units for controlling consumer electronic equipment are quite commonplace. The vast majority of these remote control units transmit modulated infrared (IR) signals to their respective devices under control of a microprocessor controller. Batteries are used as the power source for the microprocessor and IR transmitter circuitry of these wireless units. Unfortunately, batteries have a limited useful life, and are said to get "weak" and eventually "die". At some point the batteries become so weak that the remote control unit will operate erratically, or cease to operate at all. Some remote control units store user-entered preferences in volatile random access memory (RAM), which is maintained by an applied voltage from the battery. It is noted that a user may expend a considerable amount of time entering preference data during a set-up mode of operation. A user may thus be inconvenienced when his remote control loses stored preference data due to the inability of a weak or dead battery to maintain the data in memory. Clearly, a weak battery must be replaced in a timely fashion in order to prevent such a loss of data (normally, a "holding" capacitor is used to maintain a data-holding-voltage on the RAM memory chips while the battery is being replaced with a "fresh" (i.e., fully-charged") one). Thus, there is a need for a reliable weak-battery detector for detecting a weak battery condition and alerting a user that battery failure is imminent.

A prior battery-monitoring circuit is known from the CRK 22A remote control unit manufactured by RCA Corporation, Indianapolis, Indiana, and sold with the CTC 74 and CTC 81 color television chassis. In that prior circuit, the battery voltage was

not monitored automatically and continually, but rather was monitored only when a particular keyswitch was pressed. Moreover, the monitoring circuit employed a programmable unijunction transistor (PUT) biased to operate at a particular voltage by a voltage divider including an adjustment potentiometer. In such an arrangement, factory adjustment of the voltage divider is required to ensure proper operation, because each PUT has slightly different characteristics, and because the potentiometer must be preset in the correct range. It is clearly desirable to eliminate the potentiometer and its required factory set-up adjustment, and to provide for continual monitoring of the battery condition.

According to a first aspect of the present invention there is provided a remote control unit including a battery monitoring circuit for monitoring the condition of a battery, comprising:

charging means for charging to a predetermined level;

switch means for coupling said charging means to one terminal of said battery for applying battery voltage to said charging means;

a controller coupled to said switch means for controlling said switch means to apply said battery voltage to said charging means; and

timer means under control of said controller for timing a period;

said controller repeatedly timing a time period beginning when said switch means applies said battery voltage to said charging means and ending when said charging means charges to said predetermined level;

said controller generating an alarm signal when the duration of said time period exceeds a predetermined value.

Thus in accordance with the invention, a battery monitoring apparatus in a remote control

unit measures the time it takes for a charging circuit to charge from a discharged condition to a predetermined level. A weak battery takes a longer time to charge the charging circuit to the predetermined level than does a fully charged battery. The charging time associated with a fully charged battery is recorded and compared to subsequent charging time measurements. When the difference between the recorded charging time and a currently-measured charging time exceeds a predetermined value, a weak-battery alert signal is generated. In one embodiment, the alert signal is applied to a visible LED, in another embodiment, the weak-battery alert signal is transmitted to the controlled equipment which alerts the user.

According to a second aspect of the present invention, there is provided a method of determining the condition of a battery, comprising the steps of:

discharging a charging circuit;

applying voltage of said battery to said charging circuit;

timing the period in which said charging circuit charges to a predetermined threshold level;

recording said period after the first measurement;

repeating said steps and comparing each new timed period to said recorded period; and

generating an alarm signal if one of said new timed periods is greater than said recorded period by a predetermined amount.

A preferred embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawings, of which:

FIGURE 1 is an illustration of a remote control unit having a battery condition monitor in accordance with the invention;

FIGURES 2 and 3 are graphs of voltage with respect to time which are helpful in understanding the invention; and

FIGURE 4 is an illustration of a simplified flowchart showing a portion of the program code of controller 110 of FIGURE 1.

Referring to FIGURE 1, a remote control unit includes a microcomputer 110 for reading inputs of a keyboard, generally designated 120, and applying signals to be transmitted to an infrared (IR) LED transmitter arrangement, generally designated 140. The terms "microcomputer", "controller", and "microprocessor", as used herein, are equivalent. It is also recognized that the control function of microcomputer 110 may be performed by an integrated circuit especially manufactured for that specific purpose (i.e., a "custom chip"), and the term "controller", as used herein, is also intended to include such a device. Microcomputer 110 receives user-initiated commands from keyboard 120 which is mounted on the remote control unit. Microcomputer 110 includes a central processing unit (CPU) 112, a program memory (ROM) 114, and includes a random-access memory (RAM) 116. ROM 114 may be either internal to, or external to, microprocessor 110, and may also contain preprogrammed control codes for various equipment of different manufacturers. If so, RAM 116 may be used for expansion of the particular compressed set of control codes selected for each device to be controlled. Controller 110 also includes a TIMER 119, the function of which will be described below. IR LED transmitter arrangement 140, includes an IR LED designated LED 140, a driver transistor Q140, current-limiting resistors R140 and R142, and a filter capacitor C140.

Keyboard 120 includes, for example, sixteen keys, and has four drive (i.e., input) lines coupled to controller 110 at output ports D0 through D3, and four sense (i.e., output) lines coupled to controller 110 at input ports S0 through S3. In operation, keyboard 120 is scanned by applying a high level (i.e., logic level 1) signal to each of drive lines D0 through D3, in turn. After the high level signal is moved from one drive line to another, each of sense lines S0 through S3 is read to see if a high level signal is present. If so, then one of the keys of keyboard 120 must be down, completing a circuit from the active drive line to the active sense line. Controller 110 can easily determine which key is down because each key affects a unique drive line/sense line pair.

A dotted box 118 encompasses a switch SW1 which switches between a source of positive voltage and ground. Although SW1 is shown for simplicity as a mechanical switch, one skilled in the art will realize that SW1 is intended to be an electronic switch such as a bipolar transistor, or FET, output of controller 110. A battery condition measuring circuit 160, comprises a charging portion including a resistor R160 (approximately 100 kilohms) and a capacitor C160 (approximately .001 microfarads), and a detection portion including a resistor R162 (approximately 10 kilohms) and switching transistor Q160.

FIGURE 2 shows voltage versus time graphs for a fully charged battery. A nominal "5-volt battery" for supplying the +V supply voltage of the embodiment of FIGURE 1 and the graph of FIGURE 2 comprises four 1.5 volt AA batteries and a diode coupled in series (i.e., the actual supply voltage is 6 volts - 0.7 volts = 5.3 volts). At approximately 1 microsecond, a 5 volt positive-going step signal 210, having a rise time of approximately 0.1 microseconds, is applied to charging circuit R160/C160. Capacitor C160 begins charging through resistor R160 as shown in curve 215. When the voltage at the base of transistor Q160 reaches approximately 400 millivolts (at about 9 microseconds), transistor Q160 begins to switch on, reaching a fully on state when its base voltage reaches about 500 millivolts (at approximately 12 microseconds) as shown in curve 220. Thus, curve 220 is at a high level (while capacitor C160 is charging) for about 11 microseconds, when measuring a battery producing 5 volts. Transistor Q160 is actually performing as a threshold voltage detector.

FIGURE 3 shows voltage versus time graphs for a weak (i.e. 4 volt) battery. At approximately 1 microsecond, a 4 volt positive-going step signal 310, having a rise time of approximately 0.1 microseconds, is applied to charging circuit R160/C160. Capacitor C160 begins charging through resistor R160 as shown in curve 315. When the voltage at the base of transistor Q160 reaches approximately 400 millivolts (at about 11 microseconds), transistor Q160 begins to switch on, reaching a fully on state when its base voltage reaches about 500 millivolts (at approximately 14 microseconds) as shown in curve 320. Thus,

curve 320 is at a high level (while capacitor C160 is charging) for about 13 microseconds, when measuring a weaker battery (i.e., one producing only 4 volts). It is noted that it takes longer to get to a fixed predetermined voltage level in the case of the weaker battery with lower terminal voltage, because the charging rate dv/dt is lower in the case of the weak battery. That is, capacitor C160 will be fully charged in approximately five time constants. The duration of the time constant is fixed and determined by the values of R160 and C160. Therefore, in the case of a weak battery, the charging rate is lower because capacitor 160 is charging to a lower voltage in the same amount of time. Transistor Q160 will switch later when measuring a weak battery because the switching point of transistor Q160 is substantially fixed, as shown in FIGURES 2 and 3, at about 500 millivolts, and because the voltage across capacitor 160 (i.e., the switching voltage for transistor Q160) will develop over a longer period of time due to the lower charging rate. It is herein recognized that measuring the charging period and detecting a change to a longer period is an effective and reliable way to detect a weak battery condition.

Note that the actual switching point of transistor Q160 is not critical, because it will be automatically compensated for in each measurement. Note also that in the case of a weak battery, the lower switching point of controller 110 will be lowered farther (i.e.,. from about 1.5 volts guaranteed low when the supply voltage is 5 volts, to about 1.1 volts guaranteed low when the supply voltage is 4 volts). The lowering of the lower switch point of controller 110 will further delay the detection of the switching of transistor Q160 by approximately 100 nanoseconds, which is in a direction to aid in the detection of a weak battery.

As shown in the flowchart of FIGURE 4, the measurement routine is entered at step 400, where, in order to fully discharge capacitor C160 in preparation for measuring battery condition, microprocessor 110 sets switch SW1 to apply a low level signal to capacitor C160 via resistor R160. At step 410 a 100 microsecond delay is executed to allow for the discharge of capacitor C160. At step 415, switch SW1 is switched to apply the full supply voltage to monitoring circuit 160, and TIMER 119 is

started. At step 420, sense line S4 is checked for the presence of a low level signal. If a low level signal is not present, then transistor Q160 has not yet switched on, and the program loops around to step 420 again. If a low level signal is present, then transistor Q160 has switched on and the YES path is followed to step 425. At step 425, a check is made to determine if this is the first time through this routine (i.e., the first time the remote control unit has been powered-up). If so, the FIRST TIME FLAG (i.e., a location in RAM 116) will not be set, and the routine will advance to step 430. At step 430, TIMER 119 will be stopped and read, its value stored in RAM 116 and the FIRST TIME FLAG will be set. The routine will then be exited via step 450. Each time that the remote control unit is operated, this routine will once again be entered, and the measurement taken at steps 400-420. At step 425, however, the FIRST TIME FLAG will be set. This causes the routine to advance to step 435, at which TIMER 119 is stopped, its value read, and the previously-stored value subtracted from the currently-read value. If the readings differ by more than a predetermined amount (e.g., 2 microseconds) the YES path is followed to step 440 at which a WEAK BATTERY ALARM signal is generated, and the routine exited at step 450. If the readings at step 435 do not differ by the predetermined amount then the NO path is taken to the exit at step 450. It is recognized that the function of TIMER 119 may be performed without an actual hardware timer, by counting instruction cycles or decrementing the value of a count in a memory location.

In a first embodiment of the subject invention a visible-light-emitting diode (VLED) designated VLED 170 is illuminated by a WEAK BATTERY ALARM signal applied to a VLED driver circuit 170, via a current-limiting resistor R170. VLED driver arrangement 170, includes an visible-LED designated VLED 170, a driver transistor Q170, current-limiting resistors R170 and R172, and a filter capacitor C170.

In a second embodiment of the invention, VLED driver arrangement 170 is not required, because the WEAK BATTERY ALARM signal is a remote control code signal which is transmitted to the device to be controlled, which has a weak-battery warning message or symbol stored in its own ROM, and in turn alerts the

user to the weak battery condition. In the event that the device to be controlled is a video device (i.e., television set, video monitor, VCR, or videodisc player), then an on-screen message can be generated to warn the user of impending battery failure.

It should also be noted that switch SW1 performs a second function in shutting down measurement circuit 160 when controller 110 enters the sleep mode. This is accomplished by switching SW1 to apply a low level signal to measurement circuit 160, causing it to draw no current.

Thus, an arrangement has been described which provides for effective and reliable monitoring of the condition of a battery in a remote control unit. Although an IR remote control is shown in the embodiments of FIGURES 1 and 3, one skilled in the art should be aware that the invention is also applicable to remote control units which transmit radio frequency (RF) signals, and such remote control units are deemed to be within the scope of the invention. Although an IR remote control is shown in the embodiments of FIGURES 1 and 3, it is recognized that the invention is not limited to applications in remote control units, but rather may be used in other battery-powered equipment.

CLAIMS

1. A remote control unit including a battery monitoring circuit for monitoring the condition of a battery, comprising:

charging means for charging to a predetermined level;

switch means for coupling said charging means to one terminal of said battery for applying battery voltage to said charging means;

a controller coupled to said switch means for controlling said switch means to apply said battery voltage to said charging means; and

timer means under control of said controller for timing a period;

said controller repeatedly timing a time period beginning when said switch means applies said battery voltage to said charging means and ending when said charging means charges to said predetermined level;

said controller generating an alarm signal when the duration of said time period exceeds a predetermined value.

2. The remote control unit of claim 1, wherein said switch means has a first position for discharging said charging means and a second position for applying said battery voltage to said charging means.

3. The remote control unit of claim 1 or 2 wherein said switch means is an output port of said controller.

4. The remote control unit of any preceding claim, further including threshold detection means for detecting a development of a signal across said charging means at said predetermined level.

5. The remote control unit of claim 4, wherein said threshold detection means is a transistor.

6. The remote control unit of any preceding claim, wherein said alarm signal is applied to a visible LED.

7. The remote control unit of any of claims 1 to 5, wherein said alarm signal is transmitted to a device to be controlled, which device alerts a user to imminent battery failure.

8. A remote control unit substantially as herein described with reference to the accompanying drawings.

9. A method of determining the condition of a battery, comprising the steps of:

discharging a charging circuit;

applying voltage of said battery to said charging circuit;

timing the period in which said charging circuit charges to a predetermined threshold level;

recording said period after the first measurement;

repeating said steps and comparing each new timed period to said recorded period; and

generating an alarm signal if one of said new timed periods is greater than said recorded period by a predetermined amount.

10. A method of determining the condition of a battery substantially as herein described with reference to the accompanying drawings.

Patents Act 1977 **Examiner's report to the Comptroller under Section 17** **(The Search report)** -11-	Application number GB 9403929.4
Relevant Technical Fields (i) UK Cl (Ed.M) G1U (UR19165, UR3136) H3H (HAC) (ii) Int Cl (Ed.5) G01R 19/165, 31/36. H03M 1/50, 1/52	Search Examiner J BETTS Date of completion of Search 24 MAY 1994
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE DATABASES: WPI, CLAIMS	Documents considered relevant following a search in respect of Claims :- 1-9

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages	Relevant to claim(s)
X,Y	GB 2167869 A (TELECTRONICS)	X: 9 Y: 1-2,4,7
Y	EP 0501165 (LOEWE)	1-2,4,7

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